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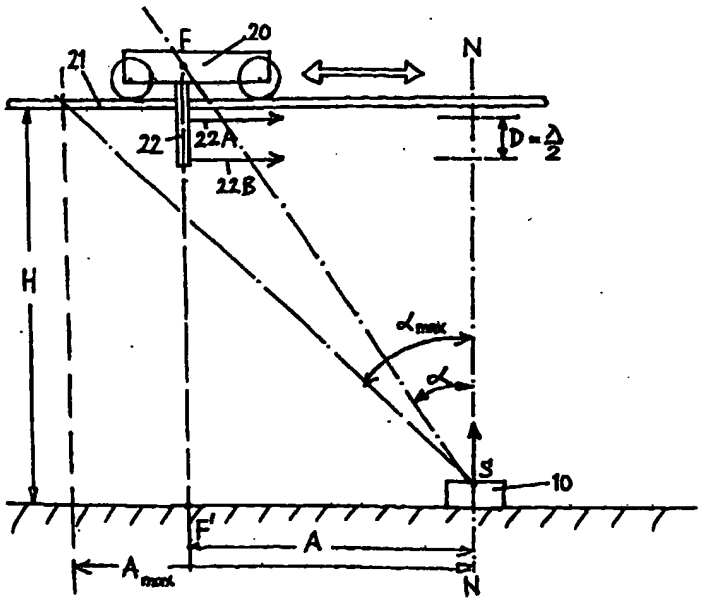
(54) Title: DEVICE FOR OBTAINING DIRECTIONAL INFORMATION IN REMOTE CONTROL SYSTEMS

(54) Bezeichnung: VORRICHTUNG ZUR GEWINNUNG EINER RICHTUNGSINFORMATION IN FERNSTEUERANLAGEN

(57) Abstract

In a device for limiting the response region of an operating device radio-controlled by a remote control transmitter, there are at least two receiving aerials on the remote-controlled operating device arranged in different positions in relation to the transmitter, from the phase-shifted reception signals of which is obtained a control signal permitting switching processes in the operating device which ensure that, when a remote-controlled device reaches a maximum distance from the remote control transmitter, a definable switching process is triggered, e.g. the stopping of the drive or the issue of an acoustic or optical warning signal. Where a plurality of remote-controlled devices are used, such a measure is increasingly required because, for example, of work safety; here, the invention provides a simple technical conversion.




(57) Zusammenfassung

Eine Vorrichtung zur Begrenzung des Ansprechbereichs eines von einem Fernsteuersender funkferngesteuerten Arbeitsgerätes sieht vor, daß mindestens zwei in unterschiedlichen Positionen zum Sender angeordnete Empfangsantennen am ferngesteuerten Arbeitsgerät angeordnet werden, aus deren phasenverschobenen Empfangssignalen ein Steuersignal gewonnen wird, das im Arbeitsgerät Schaltvorgänge veranlaßt, die sicherstellen, daß bei Erreichen einer maximalen Entfernung des ferngesteuerten Geräts vom Fernsteuersender ein definierbarer Schaltvorgang ausgelöst wird, beispielsweise eine Stillsetzung des Antriebs oder Abgabe eines akustischen oder optischen Warnsignals. Beim Einsatz einer Vielzahl von ferngesteuerten Geräten wird eine solche Maßnahme aus Gründen beispielsweise der Arbeitssicherheit zunehmend verlangt. Die Erfindung schafft hier eine einfache technische Umsetzung.

The invention relates to a device for obtaining directional information from the signal of a remote control transmitter.

Such a device is known from the publication entitled "Double-Ducky Direction Finder", in US-ZQST, July 1981, pp. 11 to 14. The device therein described has the purpose of determining the direction from which a signal to be detected comes. The signal, which is alternatingly received by the two antennas, is then processed and converted on the basis of its phase shift in such a way that an acoustic signal is issued, whose loudness is a measure of the position of the connecting axis between the two antennas on the one hand, and the connecting line between the center of this connecting axis and the transmitter; if the "direction finder" points toward the transmitter, i.e. if the connection axis of the antennas and the connecting line to the sender are located vertically on each other, the tone vanishes; with this the purpose of the known device has been accomplished.

Remote radio control devices are increasingly used in the filed of industrial remote controls, they are used, for example, for the remote control of work devices such as cranes or other construction or transportation devices, which are equipped with a suitable receiver (in this connection see DE 42 04 658 A1, for example). It is also known here to assign two receiving antennas to the receiver in order to be able, by changing the antennas, to restore the interference-free reception of the remote control data in case of a transmission interference along the radio path (DE 44 37 490 A1).

The present invention addresses a different problem:

Cross-overs of the effective ranges of several remote radio controls can arise in work areas, for example construction sites. Since as a rule workers are also present in the immediate work and effective areas themselves of the devices remote-controlled by radio, official institutions, which are concerned with the problems of work safety when industrial remote radio controls are used, increasingly demand that the range of the radio control transmitter is to be limited as exactly as possible to a defined work area. There are already proposals for standards, according to which, for example, the control of a bridge crane should only be possible in an area with a radius of approximately

10 m around the imagined extension of the lifting cable on the ground.

It is the object of the invention to further develop the device in accordance with the species in such a way that an effective and technically simple-to-execute solution of this problem of maintaining a defined work range is created.

This object is attained in accordance with the invention by a device for obtaining directional information from the signal of a remote control transmitter by a receiver, said receiver having two receiving antennas, whose respective received signal is alternatingly provided by a downstream-connected change-over switch to an evaluation circuit, which derives the direction information from the phase difference of the two received signals, said receiver with the receiving antennas mounted on a work device, which can be remotely controlled and which can be displaced in relation to the remote control transmitter within its working range on a predetermined track, wherein the phase difference of the two received signals is a measurement for the distance of the work device from the remote control transmitter, and that the evaluation circuit generates a control signal which is suitable for controlling the work device if the actual phase difference exceeds or falls below a value corresponding to a predetermined distance.

Accordingly, the basic concept of the invention resides in using the measurement of the phase shift, which is a function of the angle of incidence of the HF emission from the associated remote control radio transmitter at the location of the device to be remotely controlled in order to derive from this a safety-relevant signal, by means of which a limitation of the response range of the work device can be achieved.

A simple realization of the wiring consists in linking standard commercially available components, such as an HF receiver with an FM demodulator, for example, so that the additionally arising costs are kept within a narrow range.

An example of the use of the solution in accordance with the invention and an exemplary embodiment of the circuit used for this will now be explained in more detail by means of the drawings. Shown are in:

Fig. 1, a schematic representation of an operational range of the solution in accordance with the invention and of the parameters important for the invention,

Fig. 2, a block diagram with a schematic indication of the signal paths for generating a switching signal depending on the angle of incidence.

Fig. 1 represents a transmitter 10 shown on the ground, above which a bridge crane 20 can be horizontally moved at a height H on rails 21. The purpose of the solution in accordance with the invention is intended to be the generation of a switching signal which, for example, stops the movement of the bridge crane 20 when the connecting line between two reference points S and F between the transmitter 10 and the bridge crane 20 reaches an angle $\alpha_{max}$, measured in relation to the normal line N - N, at which the two reference points S and F are located vertically above each other. As a function of the height H it is then also possible via the maximum angle $\alpha_{max}$ to define the maximum distance $A_{max}$ of the projection of the reference point F on the ground, and therefore the extension of a lifting cable on the ground, for example.

For achieving this aim, two receiving antennas 22A, 22B are maintained, arranged one above the other, on a boom 22 of the bridge crane 20 (schematically represented), whose distance D preferably corresponds to half the wavelength (lambda/2) of the HF emission of the transmitter 10 used (with a remote control frequency of 433 MHz, D then is 345.4 mm).

If the bridge crane 20 is in its normal position (reference point F on the normal line N - N), the phase shift between the HF signal trains arriving at the two antennas 22A, 22B therefore is 180° (for angles not equal to zero, the phase shift Delta $\phi$ with the approximation H >> D is):

$$\text{Delta } \phi \equiv \frac{D \cdot 360°}{\text{lambda} \cdot \cos(\alpha/2)}$$

wherein lambda = the wavelength of the HF signals of the transmitter 10.

The desired discrimination between "permitted" angles $\alpha$ and "not permitted" angles $\alpha$ (when exceeding $\alpha_{max}$) therefore becomes possible by an appropriate discrimination of the occurring phase differences of the HF emissions of the two antennas 22A, 22B.

It should also be noted that in this case the two antennas 22A, 22B do not necessarily have to have the horizontal orientation represented in Fig. 1 by way of example, and also do not necessarily have to be arranged vertically one above the other, as long as it has been assured that a definite connection between the angle $\alpha$ on the one hand, and on the other the ensuing phase difference Delta $\phi$ exists.

The arrangement represented in Fig. 1 can also be transferred to the horizontal plane, wherein a conventional crane running on rails, for example, is then controlled.

Fig. 2 shows an example of how the two phase-shifted high-frequency signals at the two antennas 22A, 22B can be further processed in such a way that a phase shift-dependent control signal is generated, which then triggers a desired switching operation in the control device of the bridge crane 20, for example stopping the drive motor, switching on an alarm signal, or the like.

The two high-frequency signals S1 of the antenna 22A and S2 of the antenna 22B reach a change-over switch 23, which operates at a predetermined switch-over frequency $f_u$, which lies in the range of a few hundred Hertz, for example. At the time of switch-over $t_u$ the signal form which is schematically represented in sketch A results, wherein the wave trains of the two high-frequency signals S1, S2 are alternatively lined up. It can be seen from the phase shift between the two high-frequency signals represented in sketch A that the position of the bridge crane 20 does not correspond to its normal position vertically above the transmitter.

This phase modulation contained in the output signal of the change-over switch corresponds to a frequency modulation ($m = C \cdot d\phi/dt$, wherein $m$ = frequency deviation and $\phi$ = phase deviation), so that this signal can then be supplied to a normal HF receiver with an FM demodulator 24 for further evaluation. A signal as represented in sketch B is then present at its output, namely a low-frequency, pulse-shaped signal with a pulse frequency $f_u$ and a level P, which is proportional to the phase shift Delta $\phi$.

Thus, a signal which is constant to a great extent is present at a downstream-connected band-pass filter with the center frequency $f_u$ as well as a rectifier and low-pass filter arrangement 26, whose level is a clear measurement of the angle $\alpha$, as long as the latter lies within a range $0 \leq \alpha \leq \alpha_{max}$, in which a phase shift Delta $\phi$ is less than 180°. Therefore, with the example represented (D = lambda/2), the unambiguousness range for $\alpha$ (with $\cos \alpha_{max} = D/2D$) lies approximately at $0 \leq \alpha \leq 60°$, if it is assumed in a simplified manner that the distance D between the two antennas is only a first approximation for the determination of the phase shift.

A reference value corresponding to the desired value $\alpha_{max}$ can be entered via a potentiometer 27 at the negative input of the comparator 28, so that when this maximum value has been reached at the time T, the comparator 28 changes over, such as is schematically represented in sketch C. With this an unequivocal switching signal has been obtained, which is supplied to a control unit 29, in which the desired reactions are then carried out, for example the blocking of specific crane functions. It is obvious that these reactions are specific to the respective remote-controlled work device, and need not be explained here in detail.

The claims defining the invention are as follows:

1. A device for obtaining directional information from the signal of a remote control transmitter by a receiver, said receiver having two receiving antennas, whose respective received signal is alternatingly provided by a downstream-connected change-over switch to an evaluation circuit, which derives the direction information from the phase difference of the two received signals, said receiver with the receiving antennas mounted on a work device, which can be remotely controlled and which can be displaced in relation to the remote control transmitter within its working range on a predetermined track, wherein the phase difference of the two received signals is a measurement for the distance of the work device from the remote control transmitter, and that the evaluation circuit generates a control signal which is suitable for controlling the work device if the actual phase difference exceeds or falls below a value corresponding to a predetermined distance.

2. The device in accordance with claim 1, wherein a change-over switch switches between the two antenna signals at a change-over frequency for obtaining the phase-difference-dependent direction information, an HF receiver with an FM demodulator generates a sequence of pulses with the change-over frequency from the resulting signal, whose level is proportional to the phase difference.

3. The device in accordance with claim 2, wherein a signal is obtained from the pulses, whose constant amplitude is proportional to the level of the pulses, and that this signal is compared in a comparator with a reference signal, whose value defines the triggering threshold for generating the control signal.

Dated this 14th day of April, 2000.

**NBB NACHRICHTENTECHNIK GMBH**

By their Patent Attorneys:

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FIG.1

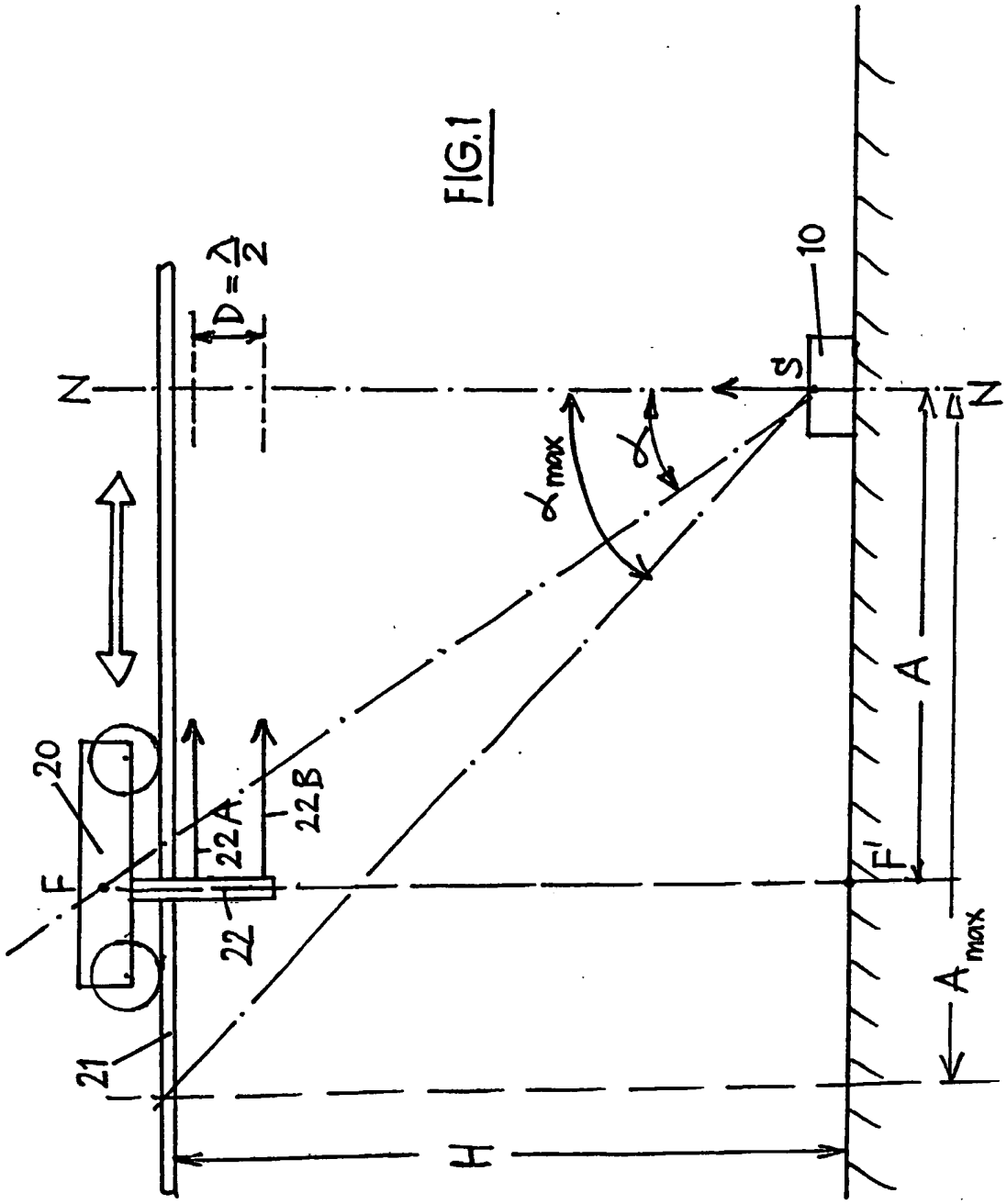

FIG.2